Elastic-Plastic and Fully Plastic Fatigue Crack Growth

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The objective of the elastic-plastic and fully plastic fatigue crack growth research effort is to develop methods and computer programs for analytically predicting lifetimes of flawed metallic structures that experience appreciable plastic crack-tip stresses. In order to reach this objective, existing elastic-plastic stress intensity (*J*-integral) solutions from the Electric Power Research Institute have been collected and combined with new analytical solutions developed from finite element solutions with the reference stress method. The list of available *J*-integral solutions is the most extensive ever collected. An overview of the solutions is as follows:

J-integral solutions for primary loads based on Electric Power Research Institute solutions and the reference stress method:

- Two-dimensional axial flaws in pressurized cylinders
- Two-dimensional circumferential flaws in cylinders, axial end force
- Two-dimensional crack from a hole in biaxial stress field
- Two-dimensional single-edge cracked plate (plane stress and plane strain)
- Two-dimensional center-cracked plate (plane stress and plane strain)
- Through wall circumferential crack, axial end force
- Through wall circumferential crack, bending moment.

J-integral solutions for primary loads based on newly developed finite element solutions and the reference stress method:

- Three-dimensional surface flaw in a finite width plate subjected to a tensile end force (two degrees of freedom—near surface and deepest point)
- Three-dimensional corner flaw in a finite width plate subjected to a tensile end force (two degrees of freedom—near surface points).

Existing linear-elastic stress intensity solutions from the NASA/FLAGRO software have been combined with limit-load solutions and cyclic stress-strain curves to provide estimates for the *J* solutions with the reference stress method. A listing of these FLAGRO geometries includes:

- TC01: through center crack subjected to tension
- TC02: through edge crack subjected to tension or bending
- TC03: through crack from an offset hole in a plate
- TC04: through crack from hole in lug
- TC05: through crack from hole in a plate with a row of holes subjected to tension or bending
- TC06: through crack in a sphere
- TC07: axial through crack in a cylinder
- TC08: circumferential through crack in a cylinder subjected to tension or bending
- TC10: circumferential through crack from a hole in a cylinder
- EC01: embedded elliptical crack subjected to tension
- CC01: corner crack in a rectangular plate subjected to tension or through wall bending
- CC02: corner crack from a hole in a plate subjected to a bending moment
- CC03: corner crack from a hole in a lug
- SC01: surface crack in a rectangular plate subjected to tension or bending
- SC03: surface crack in a spherical pressure vessel
- SC04: longitudinal surface crack in a hollow cylinder
- SC05: thumbnail crack in a hollow cylinder subjected to tension or bending
- SC07: thumbnail crack in a solid cylinder subjected to tension or bending
- SC08: thumbnail crack in a thread root in a cylinder subjected to tension or bending
- SC09: circumferential crack at a thread root in a cylinder subjected to tension or bending.

In addition to *J*-integral solutions, crack-growth algorithms have been developed for some of the flaw geometries. The associated algorithm topics include:

- Monotonic loading
- Cyclic loading
- Primary and secondary loading (mechanical and thermal)
- Combined primary loading (tension and bending)
- Crack failure
- Crack closure
- Ductile tearing
- Materials data base.

Current plans are to incorporate these solutions into the NASA/FLAGRO software in order to allow free access to interested industries and other government agencies. A preliminary list of prioritized solutions to be coded into FLAGRO will include TC01, EC01, CC01, and SC01. These solutions will have a portion of the capabilities from each crack growth algorithm currently available.

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